

# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-017472

(43)Date of publication of application : 20.01.1995

(51)Int.Cl.

B63B 39/06

B63B 1/24

B63B 1/28

(21)Application number : 04-362183

(71)Applicant : FUJII YUSAKU

(22)Date of filing : 24.11.1992

(72)Inventor : FUJII YUSAKU

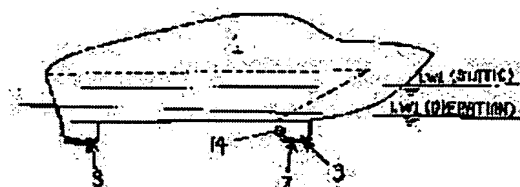
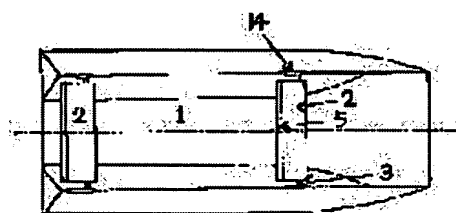
(54) SHIP

(57)Abstract:

PURPOSE: To prevent the change in the position in the pitching direction of the hull by waves, etc., by providing the support by a bearing to freely allow the rotation in the direction to change the angle of attack, and providing a hydrofoil of a shape to achieve the stabilization by the angle of attack to generate the lift by the flow of the fluid.

CONSTITUTION: A hull 1 is provided with one or more hydrofoils 2 supported by a bearing 4 which freely allows the rotation of a rotary shaft 3 in the direction to change the angle of attack. The hydrofoil 2 may be supported in the divided manner in the breadth direction. Alternatively, the hydrofoil 2 may be formed of the shape to stabilize the angle of attack

to generate the lift sufficient to support the weight of the hull 1 when the ship is navigating. In addition, the hydrofoil 2 may be provided with an auxiliary foil to stabilize the main foil at an appropriate angle of attack. On the other hand, the shape of the foil may be of variable type. The position of the bearing which freely allows the rotation of the rotary shaft 3 is set in the vicinity of the position of gravity of the hull 1. This constitution prevents the change in the position in the pitching direction of the hull 1.



## LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of

**BEST AVAILABLE COPY**

rejection]

[Kind of final disposal of application other  
than the examiner's decision of rejection or  
application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's  
decision of rejection]

[Date of requesting appeal against  
examiner's decision of rejection]

[Date of extinction of right]

\* NOTICES \*

JPO and NCIPi are not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

CLAIMS

---

[Claim(s)]

[Claim 1] The vessel characterized by having the hydrofoil of one or more sheets supported by the bearing which allows freely rotation of the direction to which an angle of incidence is changed.

[Claim 2] The vessel according to claim 1 characterized by dividing a hydrofoil crosswise and supporting it.

[Claim 3] The vessel according to claim 1 or 2 characterized by having the hydrofoil which has the shape of a profile which is stabilized by the angle of incidence which generates the lift which is sufficient for supporting a part or all of weight of a hull at the time of transit, or a hydrofoil with the aileron which stabilizes a main plane by the suitable angle of incidence.

[Claim 4] The vessel according to claim 1, 2, or 3 characterized by making the shape of a profile adjustable.

[Claim 5] Claim 1 characterized by carrying out the location of the bearing which allows freely rotation of the direction to which an angle of incidence is changed near the center-of-gravity location of a hull, or a vessel according to claim 2, 3, or 4.

---

[Translation done.]

\* NOTICES \*

JPO and NCIPi are not responsible for any damages caused by the use of this translation.

- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.\*\*\*\* shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

---

DETAILED DESCRIPTION

---

[Detailed Description of the Invention]

[0001]

[Industrial Application] Especially this invention relates to the vessel it runs at high speed and which has a hydrofoil about a vessel.

[0002]

[Description of the Prior Art]

[Problem(s) to be Solved by the Invention] Conventionally, for the wave making resistance which becomes large rapidly with increase of a rate, and a viscous pressure drag, as a means to tear the wall of the rate which is not exceeded, the vessel of a skid mold, the vessel of the surfacing mold according to a hydrofoil further, etc. are devised, and it is widely put in practical use by vessel of a displacement mold. Especially, in the vessel of the surfacing mold by the hydrofoil, wave making resistance is almost lost, and since it becomes the pressure drag and frictional resistance which act on a hydrofoil and its stanchion, resistance becomes small sharply and can attain a big travel speed under small power.

[0003] However, in order to make it a hydrofoil not come out on the water surface as the velocity vector of a vessel is always horizontally maintained depending on this method and a hull does not collide with the water surface, the actuator for changing the configuration or angle of incidence of a measurement control device and a hydrofoil is needed.

[0004] Although there is also a method of stabilizing the posture of a hull with the aileron connected with a fin which goes into the water surface halfway, and it, it is hard to say into a billow that it is practical. This invention aims at offering the vessel which has the hydrofoil which cannot receive easily the posture fluctuation of a hull or the effect of a wave which make it possible to attain a big rate without attitude control equipment under small power with simple attitude control equipment for the small vessel which cannot carry complicated attitude control equipment especially easily.

[0005]

[Means for Solving the Problem] This invention is a vessel characterized by the following matters. It is the vessel characterized by having the hydrofoil of one or more sheets supported by the bearing which allows freely rotation of the direction to which an angle of incidence is changed. Especially, crosswise, when flow is uneven, there is a vessel characterized by dividing an aerofoil crosswise and supporting it to produce the lift distribution crosswise positively for the purpose, such as attitude control.

[0006] There is a vessel characterized by having the hydrofoil which has the shape of a profile which is stabilized by the angle of incidence which generates the lift which is sufficient for supporting a part or all of weight of a hull at the time of transit as an example of this vessel, or a hydrofoil with the aileron which stabilizes a main plane by the suitable angle of incidence. Furthermore, in order to optimize the lift which a hydrofoil generates according to a run state, there is a vessel characterized by making the shape of a profile adjustable. When the posture of a hull is especially changed in a billow, in order for the force of acting on a hull from a hydrofoil not to carry out induction of the pitch angle fluctuation of a hull, there is a vessel characterized by carrying out the location of the bearing which allows freely rotation of the direction to which an angle of incidence is changed near the center-of-gravity location of a hull.

[0007] Now, drawing for explaining the basic configuration of the vessel by this invention to

drawing 1 is shown. In drawing 1, the hydrofoil 2 attached in the hull 1 through the revolving shaft 3 and the bearing 4 serves as the configuration where the aerofoil posterior part (trailing-edge section) 5 leaped up up, and when supported with the revolving shaft 3 arranged on the suitable location, it serves as a configuration which is stabilized by the angle of incidence which generates lift at the time of transit. Furthermore, control of the time average value of the lift which it is possible to change the angle of incidence of an aerofoil according to the small force by the aerofoil posterior part's 5 bounding and controlling a raising include angle actively, and a hydrofoil generates -- control for oscillating control of a hull can also be easily performed by the small force further more positively.

[0008] In addition, in order to enlarge effectiveness as an aerofoil, as for the location of a revolving shaft 3, considering as the front a little is more desirable than the aerodynamic center of an aerofoil. In this example, the hull serves as a catamaran mold. In this case, when not controlling the configuration of a hydrofoil, as for a part of weight of a hull, it is desirable to make it take charge with a displacement and to maintain the independence stability of the posture of a hull. On the other hand, in controlling the shape of a profile according to the run state at that time, and the posture of a hull, it becomes possible to surface a hull completely and to run a hull, and the resistance at the time of transit becomes still smaller.

[0009]

[Function] Drawing for explaining the working principle of the hydrofoil used for drawing 2 in this invention is shown. Although the shape of a wing section of a hydrofoil 2 had turned into the configuration where the aerofoil posterior part 5 leaped up up, in drawing 1 In an certain angle of incidence which the reason made into such a configuration becomes as [ show / distribution of the differential pressure of an aerofoil vertical side / when this aerofoil is placed into a uniform flow / drawing 3 ], and produces lift as the whole aerofoil It is for the moment which acts from the aerofoil posterior part 5 to negate the moment (moment which acts on the sense which is going to make the angle of incidence of an aerofoil small) which acts on the surroundings of the revolving shaft 3 of a blade from the aerofoil anterior part 6. By doing in this way, the aerofoil supported with the revolving shaft 3 is stabilized, where it has the angle of incidence which generates lift in the flow of a fluid as shown in drawing 2 (b). In this example, the lift as the whole aerofoil is equal to resultant force with the lift 8 which acts on the aerofoil anterior part 6, and the negative lift 7 which acts on the aerofoil posterior part 5. In addition, lift 8 and the moment hung mutually can be generated by the smaller force, so that the point of application of lift 7 is kept away from a revolving shaft 3 compared with the point of application of lift 8.

[0010] Here, supposing a hull will be in a head raising condition under the effect of a billow etc., it follows in footsteps of rotation of a hull for the frictional resistance of a revolving shaft 3 and a bearing 4 and the angle of incidence of a hydrofoil increases temporarily, the upward force 8 which the downward force 7 committed at the aerofoil posterior part 5 decreases as shown in drawing 2 (a), and is committed to the aerofoil anterior part 6 will increase. Thereby, the moment 9 of head lowering arises around a revolving shaft 3, and an aerofoil angle of incidence decreases. On the contrary, the upward force 8 which a hull will be in a head lowering condition, the downward force 7 committed at an aerofoil posterior part increases as shown in drawing 2 (c) when the angle of incidence seen from the aerofoil decreases, and is committed to the aerofoil anterior part decreases. Thereby, the moment 10 of head raising arises around a revolving shaft 3, and increases a blade angle of incidence. Thus, an aerofoil angle of incidence falls to an certain angle of incidence as finally shown in drawing 2 (b) automatically, and is attached to it. That is, a hydrofoil 2 holds a fixed angle of incidence to a stream irrespective of posture fluctuation of a hull.

[0011] Therefore, as shown in drawing 4 (a) - (c), without being based on the posture of a hull, to a stream, an aerofoil becomes possible [ holding a fixed angle of incidence automatically ], and it becomes possible to make almost fixed lift (resultant force of reaction) act to a hull through a revolving shaft 3 of it. In addition, the responsibility of actuation of angle-of-incidence adjustment of the aerofoil to disturbance becomes high, so that rotation frictional resistance of a revolving shaft 3 is made small, and, so that mass of an aerofoil is made small. It becomes possible by the aerofoil posterior part's having bounded here according to a run state, and controlling an angle to adjust the magnitude of the force which a hydrofoil generates. For example, it becomes possible to maintain

the lift which an aerofoil generates to constant value, without being based on the rate of a hull by making the configuration of an aerofoil into the \*\*\*\* configuration which the angle of incidence of an aerofoil stabilizes with a small value as the rate of a hull becomes large.

[0012] By carrying out like this, a part of weight of a hull is made to always take charge of with a displacement, and it becomes possible to hold the independence stability of a hull, for example. Moreover, it is the purpose which controls vibration of the hull by disturbance, such as a wave, and it is also possible to control the lift which an aerofoil generates. The lift which generates all the weight of a hull by the hydrofoil is made to take charge as this example, and in order to cope with the force changed in time of acting on a hull according to disturbance, such as a wave, it is possible to control the shape of a profile.

[0013] As shown in drawing 5, by dividing an aerofoil crosswise and supporting it, when the flow direction is uneven crosswise, it becomes possible to make small the difference of the angle of incidence of each aerofoil 2-1 - N, and the effectiveness as the whole aerofoil improves. Moreover, by the aerofoil posterior part 5-1 of each aerofoil - N having bounded, and controlling an angle, it becomes possible to control the lift which acts on each aerofoil according to an individual, and the attitude control of the rolling direction of a hull becomes possible.

[0014] In addition, when supported not only with this example but with a revolving shaft as a configuration of an aerofoil, as long as it is the three-dimension configuration which is stabilized where it has the angle of incidence which generates lift in the flow of a fluid, you may be what kind of configuration, and the same effectiveness may be produced by adding an aileron. Moreover, when generating of cavitation cannot be controlled by the reasons nil why wing loading is large etc., as a profile, a supercavitation profile is suitable. Moreover, constraint is prepared in a bearing 4 and a revolving shaft 3 for the purpose of preventing that an aerofoil touches a hull, and rotation may be made to allow only by within the limits with a hydrofoil 2.

[0015] Drawing for explaining an example of the shape of a profile of a hydrofoil to drawing 6 is shown. The hydrofoil 2 consists of the lift generating section 11 and an angle-of-incidence control section 12 attached in those both ends in this example. The lift generating section 11 is supported with the revolving shaft 3 located near [ the ] an aerodynamic center, and the angle-of-incidence control section 12 is supported with the revolving shaft 13 located near the trailing edge of the lift generating section 11. The relative-angle-of-attack difference of the angle-of-incidence control section 12 and the lift generating section 11 is controlled by the servo motor by the include angle of arbitration through a revolving shaft 13. If the angle-of-incidence control section 12 is fixed so that it may have a negative angle of incidence to the lift generating section 11, a hydrofoil 2 will be stabilized by the angle of incidence which generates lift in flow.

[0016] In addition, it is not dependent on the include angle of a stanchion 14, therefore does not depend on the include angle of the pitching direction of a hull for the lift vector to generate. Drawing for explaining an example of the shape of a profile of a hydrofoil to drawing 7 is shown. The hydrofoil 2 is constituted from the supporting structure 17 which fixes the main plane 15 which generates lift, the aileron 16 for stabilizing a main plane by the fixed angle of incidence in flow, and a main plane and an aileron by this example.

[0017]

[Example] The example which applied this invention to the vessel of a skid mold at drawing 8 is shown. If it is made for a hull to have one half extent of hull weight supported from a hydrofoil at the time of a skid, while enabling it for resistance to become small and to attain a big rate under small power, it becomes possible by supporting the weight of one half extent according to the force from a skid side to maintain the independence stability of a posture.

[0018] The example which applied this invention to the vessel of a skid mold at drawing 9 is shown. The location of a revolving shaft 3 is made into near [ center-of-gravity location 18 ] a hull in this example. By doing in this way, it becomes possible to make it the force of acting from a hydrofoil at the time of posture fluctuation of a hull not serve as the angular moment of the pitching direction of a hull.

[0019]

[Effect of the Invention] By being supported by the bearing which allows freely rotation of the direction to which an angle of incidence is changed in this invention, and considering as the vessel

which gave the hydrofoil of the configuration stabilized by the angle of incidence which generates lift in the flow of a fluid, as stated above [ when posture fluctuation of the pitching direction arises in a hull according to disturbance, such as a wave, ] It becomes possible to make eternal lift which becomes possible [ making eternal the angle of incidence of a hydrofoil to the flow of a fluid ], with a hydrofoil generates, and it becomes possible to offer the vessel which has the hydrofoil which cannot be easily influenced by the hull of posture fluctuation.

---

[Translation done.]

\* NOTICES \*

JPO and NCIPi are not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

DESCRIPTION OF DRAWINGS

---

[Brief Description of the Drawings]

[Drawing 1] Drawing for explaining the basic configuration of a vessel by this invention.

[Drawing 2] Drawing for explaining the principle of the automatic optimization of an aerofoil angle of incidence by this invention.

[Drawing 3] Differential pressure distribution of the aerofoil vertical side of a hydrofoil by this invention.

[Drawing 4] Drawing for explaining the mechanism from which the magnitude and the direction of a fluid force which a hydrofoil generates at the time of the pitching vibration of a vessel by this invention become eternal.

[Drawing 5] Drawing for explaining the example of a configuration of a hydrofoil by this invention.

[Drawing 6] Drawing for explaining the example of a configuration of a hydrofoil by this invention.

[Drawing 7] Drawing for explaining the example of a configuration of a hydrofoil by this invention.

[Drawing 8] The example which applied this invention to the vessel of a skid mold.

[Drawing 9] The example which applied this invention to the vessel of a skid mold.

[Description of Notations]

1 Hull

2 Hydrofoil

3 Revolving Shaft

4 Bearing

5 Aerofoil Posterior Part

6 Aerofoil Anterior Part

7 Resultant Force of Lift Which Acts on Aerofoil Posterior Part or Lift, and Reaction

8 Resultant Force of Lift Which Acts on Aerofoil Anterior Part or Lift, and Reaction

9 Head Lowering Moment

10 Head Raising Moment

11 Lift Generating Section

12 Angle-of-Incidence Control Section

13 Revolving Shaft of Angle-of-Incidence Control Section 12

14 Stanchion

15 Main Plane

16 Aileron

17 Supporting Structure

18 Center-of-Gravity Location

---

[Translation done.]



## \* NOTICES \*

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

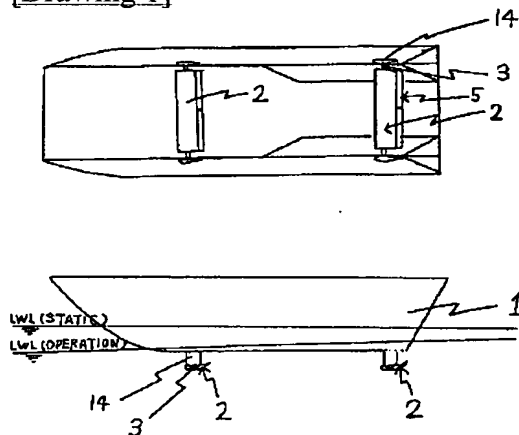
1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. \*\*\*\* shows the word which can not be translated.

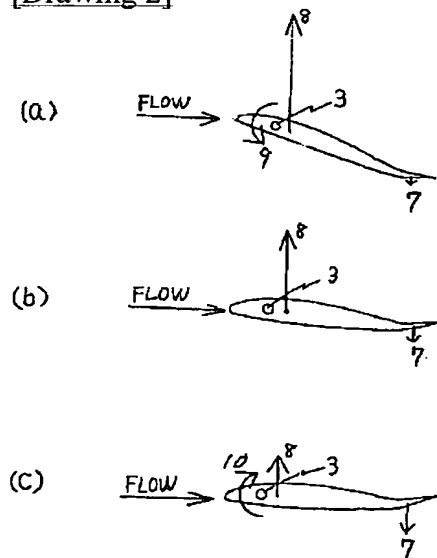
3. In the drawings, any words are not translated.

## DRAWINGS

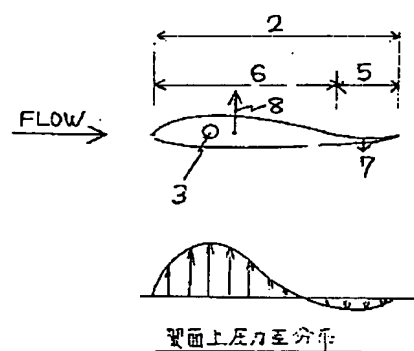
[Drawing 1]



[Drawing 2]

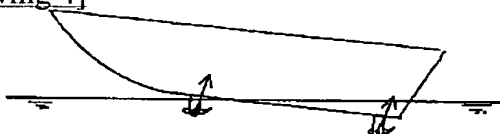


[Drawing 3]

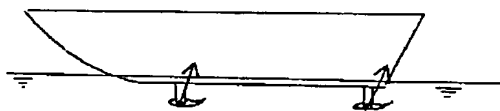


[Drawing 4]

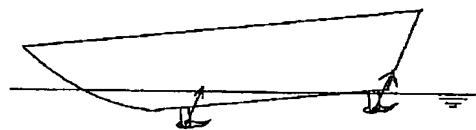
(a)



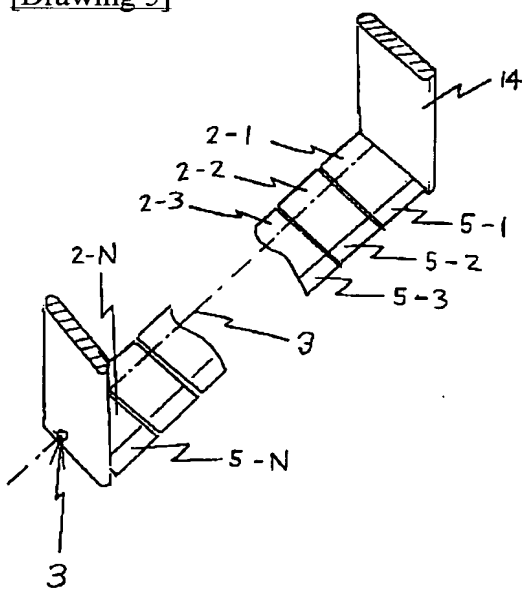
(b)



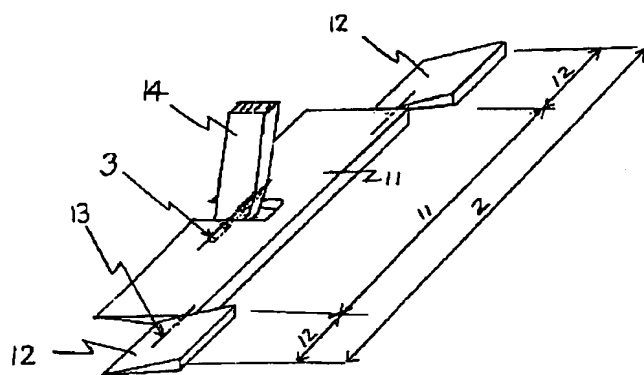
(c)



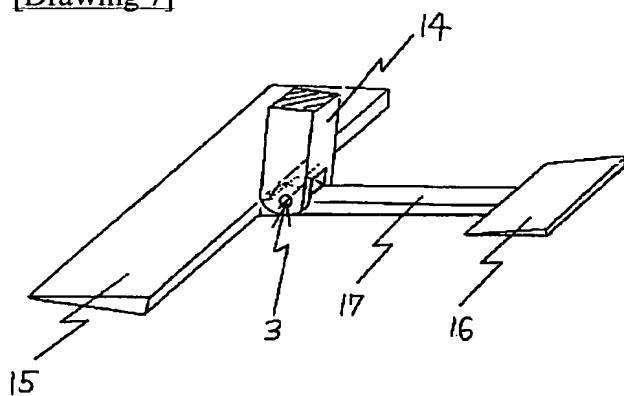
[Drawing 5]



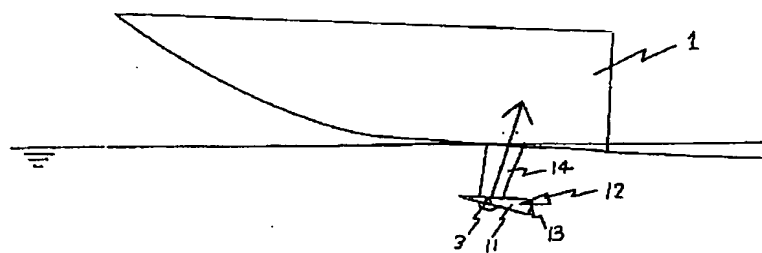
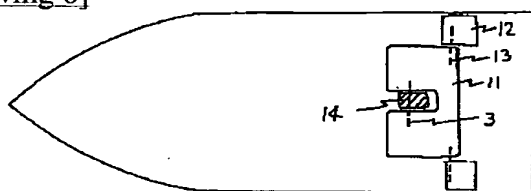
[Drawing 6]



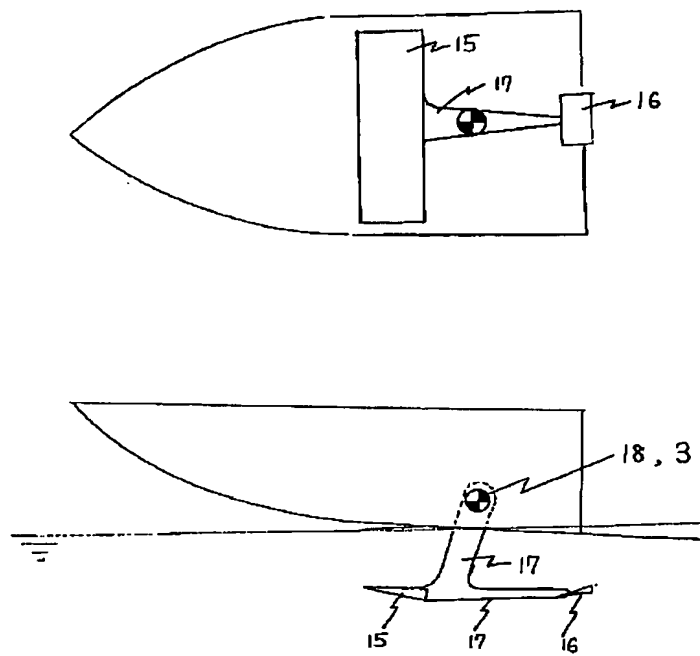
[Drawing 7]



[Drawing 8]



[Drawing 9]



---

[Translation done.]

## \* NOTICES \*

JPO and NCIPi are not responsible for any damages caused by the use of this translation.

- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.\*\*\*\* shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

---

 WRITTEN AMENDMENT
 

---

----- [a procedure revision]

[Filing Date] December 20, Heisei 5

[Procedure amendment 2]

[Document to be Amended] Specification

[Item(s) to be Amended] 0008

[Method of Amendment] Modification

[Proposed Amendment]

[0008] In addition, in order to enlarge effectiveness as an aerofoil, as for the location of a revolving shaft 3, considering as the front a little is more desirable than the aerodynamic center of an aerofoil. In this example, the hull serves as a catamaran mold. In this case, when not controlling the configuration of a hydrofoil, as for a part of weight of a hull, it is desirable to make it take charge with a displacement and to maintain the independence stability of the posture of a hull. On the other hand, in controlling the shape of a profile according to the run state at that time, and the posture of a hull, it becomes possible to surface a hull completely and to run a hull, and the resistance at the time of transit becomes still smaller. Some explanation is further given about the mechanism of this lift automatic stabilization. With the aerofoils of the configuration where the trailing edge leaped up, the moment coefficient of the circumference of an aerodynamic center serves as forward (the direction which raises first transition, direction which will increase an angle of incidence  $\alpha$  if it puts in another way), and stabilizes an aerofoil by the angle of incidence which generates lift forward in the inside of a uniform flow by making the location of a revolving shaft 3 into the front (first transition approach) from an aerodynamic center. Generally the moment coefficient of the circumference of the aerodynamic center of an aerofoil with a negative camber (negative curvature ratio) serves as forward, and as for this inclination, it is so desirable that the maximum curvature location from first transition is close to a trailing edge to consider as the configuration where adjusted near the trailing edge to increase and increase a moment coefficient, without worsening a L/D ratio, and the trailing edge leaped up. In addition, in order to enlarge effectiveness as an aerofoil, as for the moment coefficient of the circumference of the aerodynamic center of an aerofoil, it is desirable that they are +0.01 to about 0.1 and a forward small value, therefore, as for the location of a revolving shaft 2, considering as the front a little is more desirable than the aerodynamic center of an aerofoil. The configuration of various profiles and the relation of a property are I.H.Abbott. et al., Summary of Airfoil Data, NACA Report No.824, (1945), I. H.Abbott and A.E.vonDoenhoff, Theory of Wing Sections, Dover Publications, Inc., N.Y., (1959), F. W.Riegels, Aero-foil It is investigated by the detail by Sections, Butterworths, London (1961), etc. In case this invention is carried out, there are many cases which adopt the profile which has a negative camber, but about the profile which has the relation of a mirror image mutually to a chord line, that what is necessary is just to reverse a y-coordinate shaft perpendicular to a chord line, since an angle of incidence  $\alpha$ , a lift coefficient CL, and moment coefficient-C M make a sign reverse and should just consider it, the abundant data of said reference can be used also in this case. In addition, this whole aerofoil is stabilized by the angle of incidence  $\alpha$  which generates lift in flow by considering as a configuration from which the moment of the circumference of the aerodynamic center of the whole aerofoil serves as forward like [ aerofoil / whole ] the above-mentioned, and making the location of a revolving shaft 3 into the

front (leading edge approach) a little than the aerodynamic center of the whole aerofoil.

[Procedure amendment 3]

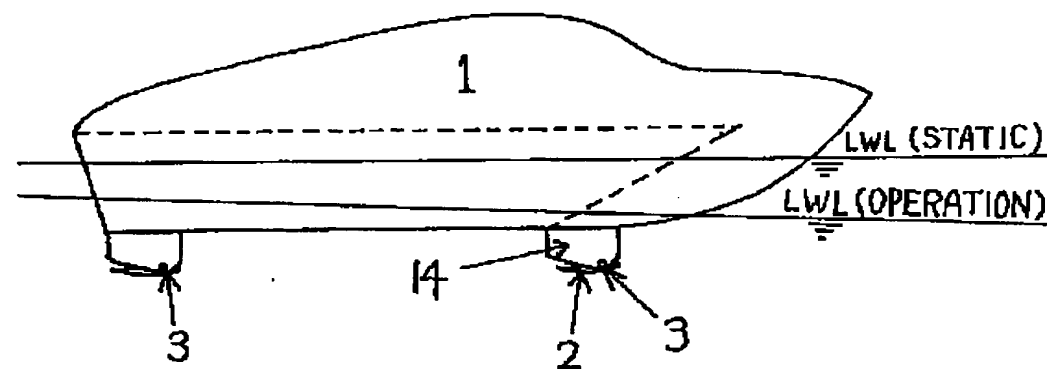
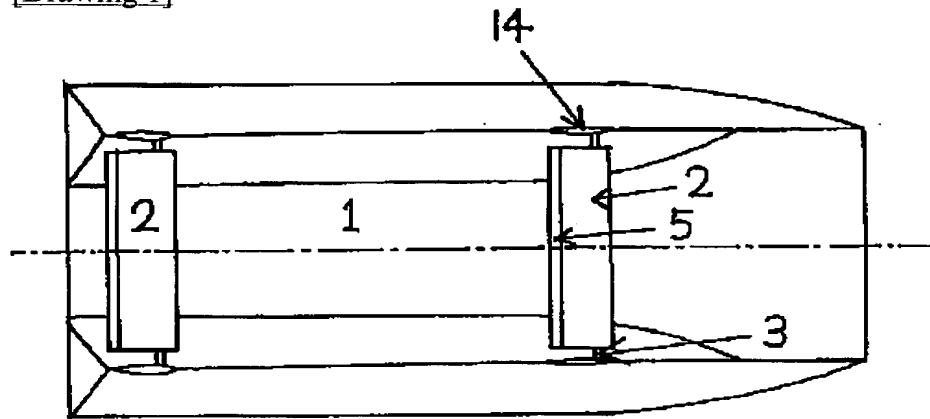
[Document to be Amended] DRAWINGS

[Item(s) to be Amended] Complete diagram

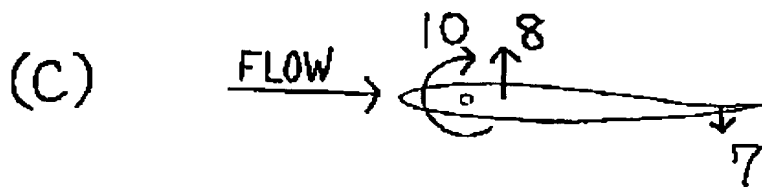
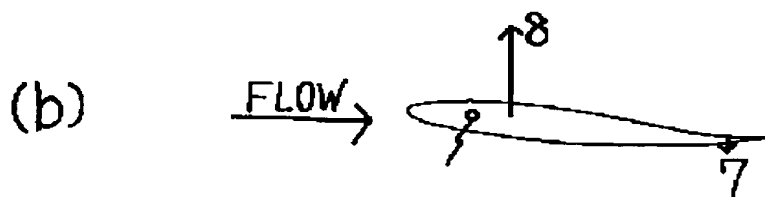
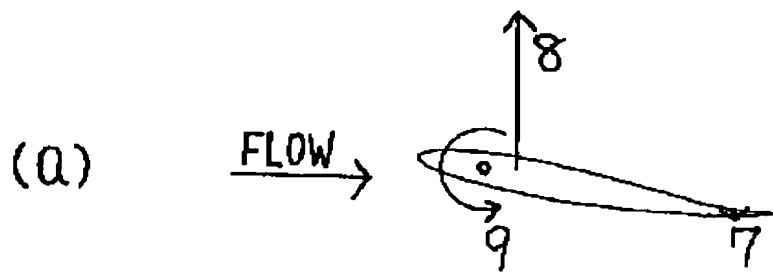
[Method of Amendment] Modification

[Proposed Amendment]

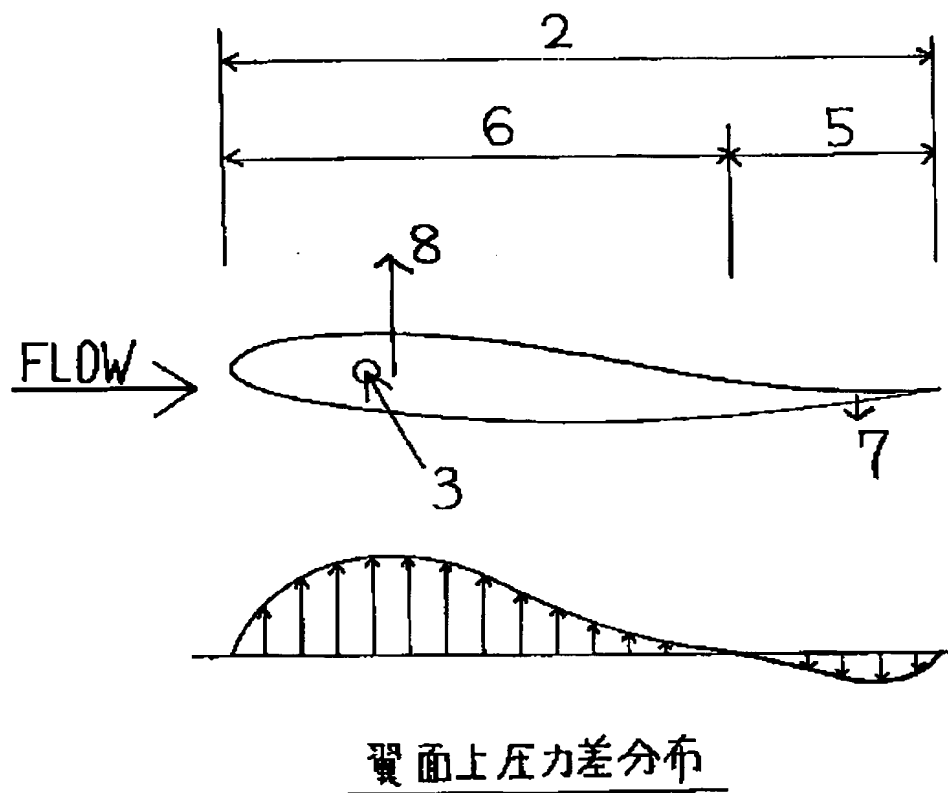
[Drawing 1]



[Drawing 2]



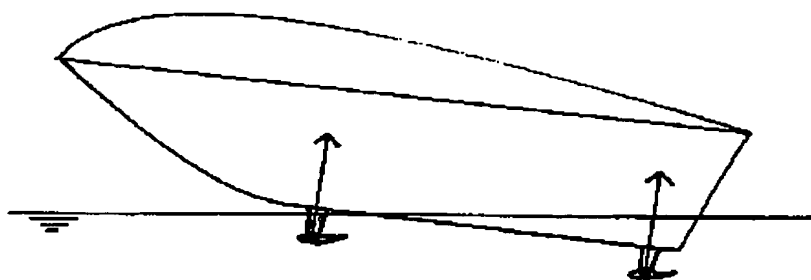
[Drawing 3]



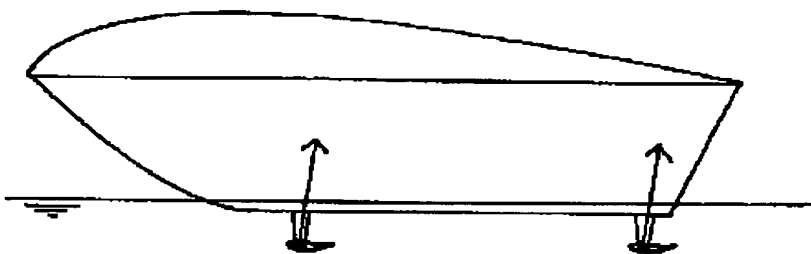
[Drawing 4]



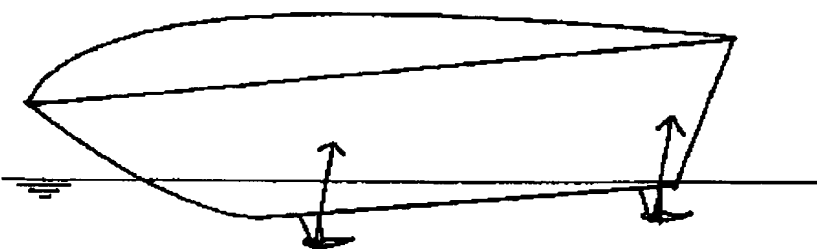
(a)



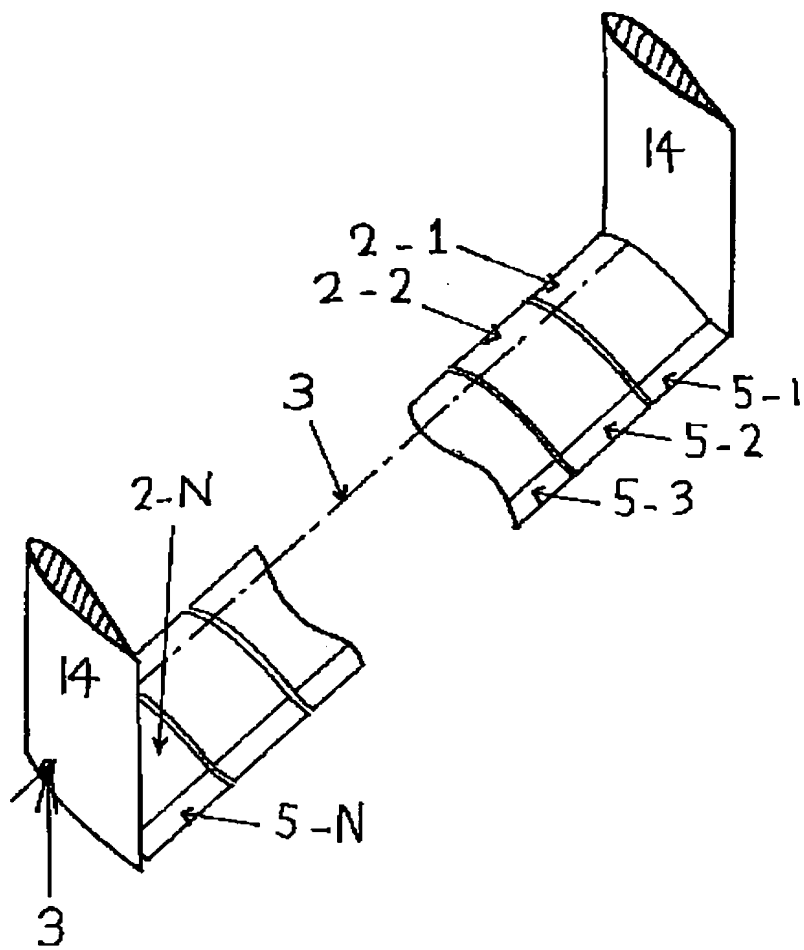
(b)



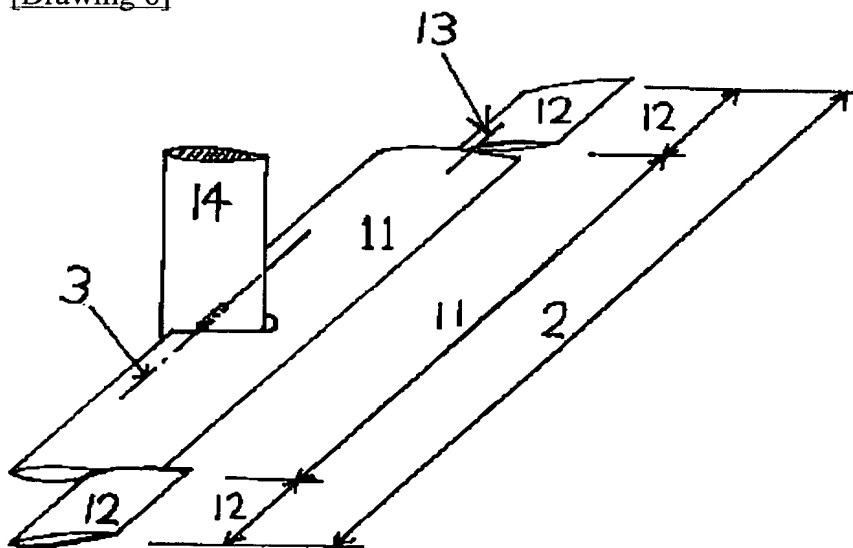
(c)



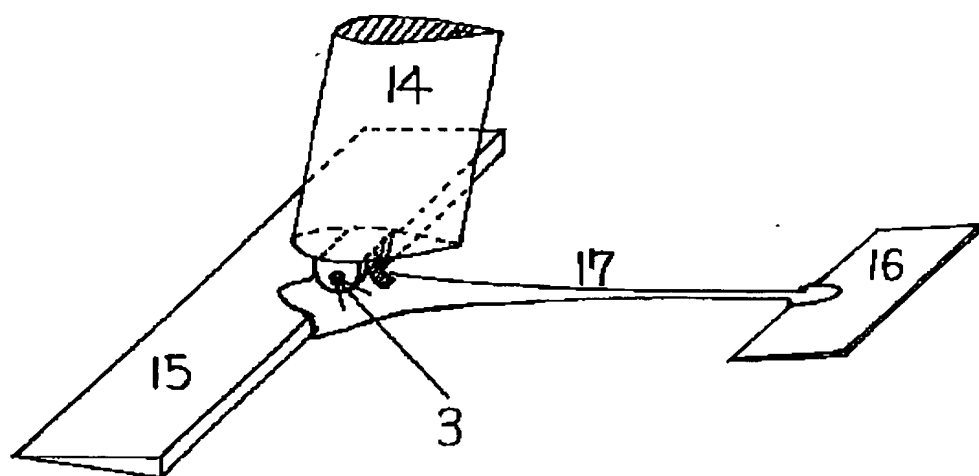
[Drawing 5]



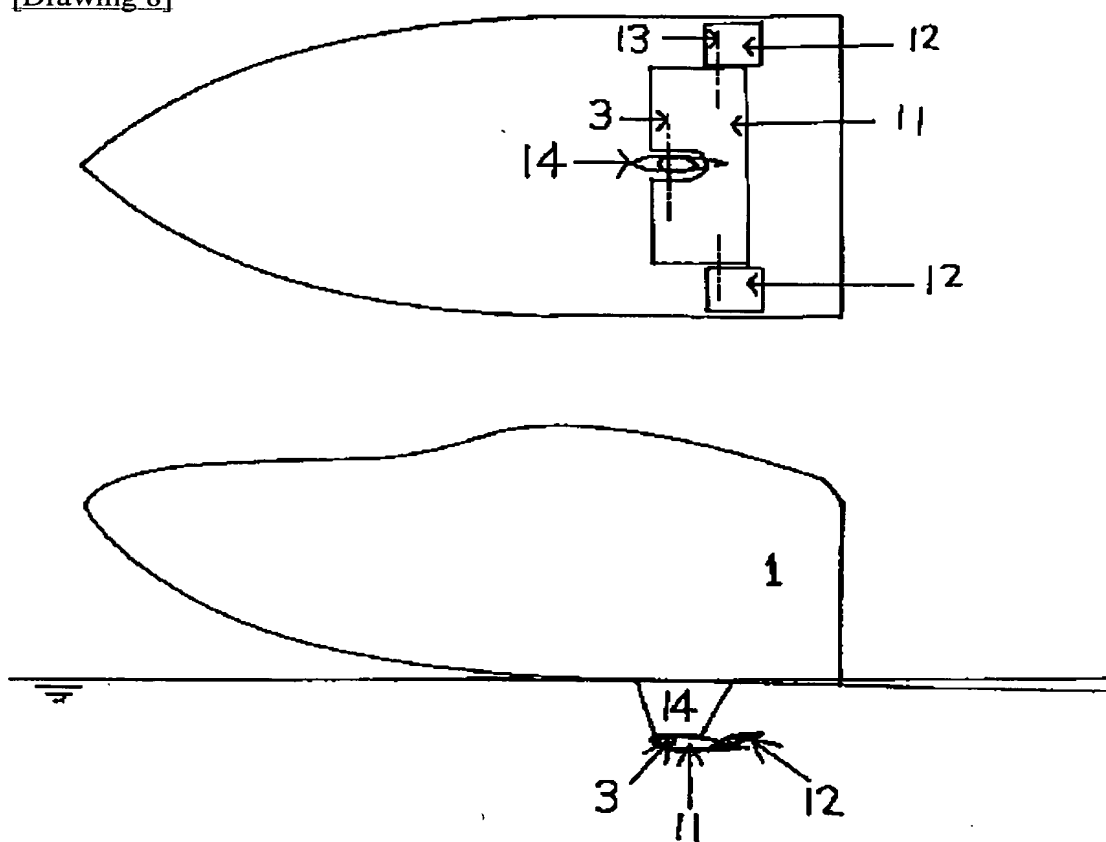
[Drawing 6]



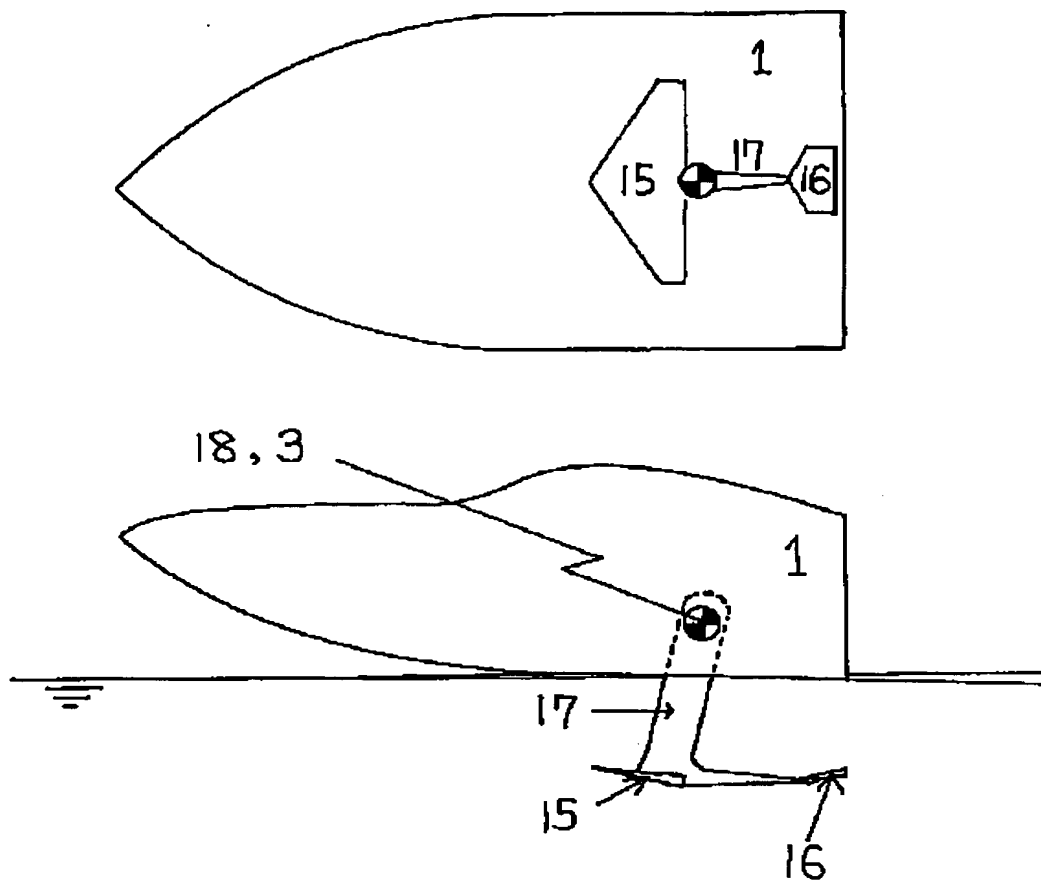
[Drawing 7]



[Drawing 8]



[Drawing 9]



---

[Translation done.]

(19)日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11)特許出願公開番号

特開平7-17472

(43)公開日 平成7年(1995)1月20日

(51)Int.Cl. <sup>6</sup>	識別記号	序内整理番号	F I	技術表示箇所
B 6 3 B 39/06	D	7626-3D		
1/24		7626-3D		
1/28		7626-3D		

審査請求 未請求 請求項の数5 書面 (全 9 頁)

(21)出願番号 特願平4-362183

(22)出願日 平成4年(1992)11月24日

(71)出願人 592242752

藤井 雄作

静岡県下田市数根765-9

(72)発明者 藤井 雄作

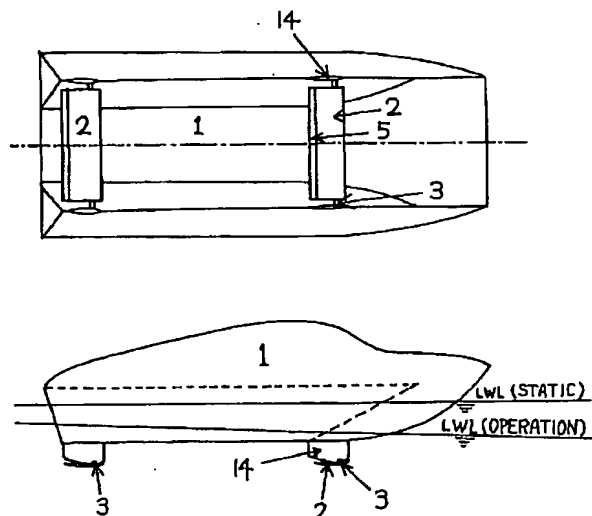
神奈川県大和市深見台4丁目14番6号

(54)【発明の名称】 船 舶

(57)【要約】

【目的】 波等による船体のピッチング方向の姿勢変動の影響を受けにくい、水中翼を有する船舶を提供することを目的とする。

【構成】 迎角を変化させる方向の回転を自由に許す軸受けにより支持され、流体の流れの中で揚力を発生する迎角で安定化する形状の水中翼を付与した船舶とすることにより、波等の外乱により船体にピッチング方向の姿勢変動が生じた場合において、流体の流れに対する水中翼の迎角を不変とすることが可能となり、以て、水中翼の発生する揚力を不変とすることが可能となり、船体の姿勢変動の影響を受けにくい水中翼を有する船舶を提供することが可能となる。



## 【特許請求の範囲】

【請求項 1】 迎角を変化させる方向の回転を自由に許す軸受けにより支持された 1 枚以上の水中翼を持つことを特徴とする船舶。

【請求項 2】 水中翼を幅方向に分割して支持することを特徴とする請求項 1 に記載の船舶。

【請求項 3】 走行時において、船体の重量の一部または全部を支持するに足る揚力を発生させる迎角で安定化するような翼形状を有する水中翼、あるいは、主翼を適10 当な迎角で安定化させる補助翼を持った水中翼をもつことを特徴とする、請求項 1 または請求項 2 に記載の船舶。

【請求項 4】 翼形状を可変とすることを特徴とする、請求項 1 または請求項 2 または請求項 3 に記載の船舶。

【請求項 5】 迎角を変化させる方向の回転を自由に許す軸受けの位置を船体の重心位置近傍とすることを特徴とする、請求項 1 または請求項 2 または請求項 3 または請求項 4 に記載の船舶。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は、船舶に関し、特に、高速で走行する、水中翼を有する船舶に関する。

## 【0002】

## 【従来の技術】

【発明が解決しようとする課題】従来、速度の増大と共に急激に大きくなる造波抵抗、粘性圧力抵抗のために、排水量型の船舶では超えられない速度の壁を破る手段として、滑走型の船舶、さらには、水中翼による浮上型の船舶等が考案され、広く実用化されている。特に、水中翼による浮上型の船舶においては、造波抵抗がほとんどなくなり、水中翼およびその支柱に作用する圧力抵抗と摩擦抵抗のみとなるために、抵抗が大幅に小さくなり小さな動力で大きな走行速度を達成できる。

【0003】しかしながら、この方式によっては、船舶の速度ベクトルを常に水平に維持し、船体が水面に衝突しないように、かつ、水中翼が水面上に出てしまわないようにするために、計測制御装置、および、水中翼の形状または迎角を変えるためのアクチュエーターが必要となる。

【0004】水面上に半ば入るようなフィンとそれに連結した補助翼により船体の姿勢を安定化させる方法もあるが、波浪中においては実用的とはいえない。本発明は、特に、複雑な姿勢制御装置を搭載しがたい小型の船舶を対象として、姿勢制御装置なしで、あるいは、簡略な姿勢制御装置によって、小さな動力で大きな速度を達成することを可能とする、船体の姿勢変動や波の影響をうけにくい水中翼を有する船舶を提供することを目的とする。

## 【0005】

【課題を解決するための手段】本発明は、以下の事項を

特徴とする船舶である。迎角を変化させる方向の回転を自由に許す軸受けにより支持された 1 枚以上の水中翼を持つことを特徴とする船舶である。特に、幅方向に流れが不均一である場合、あるいは、姿勢制御等の目的により積極的に幅方向に揚力分布を生じさせたい場合においては、翼を幅方向に分割して支持することを特徴とする船舶がある。

【0006】この船舶の例として、走行時において、船体の重量の一部または全部を支持するに足る揚力を発生させる迎角で安定化するような翼形状を有する水中翼、あるいは、主翼を適当な迎角で安定化させる補助翼を持った水中翼をもつことを特徴とする船舶がある。さらに、走行状態に応じて、水中翼の発生する揚力を最適化するために、翼形状を可変とすることを特徴とする船舶がある。とくに、波浪中において船体の姿勢が変動した場合において、水中翼から船体に作用する力が船体のピッチ角変動を誘起させないようにするために、迎角を変化させる方向の回転を自由に許す軸受けの位置を船体の重心位置近傍とすることを特徴とする船舶がある。

20 【0007】さて、図 1 に本発明による船舶の基本構成を説明するための図を示す。図 1 において、船体 1 に、回転軸 3 と軸受け 4 を介して取り付けられた水中翼 2 は、翼後部（後縁部）5 が上方に跳ね上がった形状となっており、適当な位置に配した回転軸 3 により支持されたとき、走行時に揚力を発生する迎角で安定化するような形状となっている。さらに、翼後部 5 の跳ね上げ角度を能動的に制御することにより、小さな力により翼の迎角を変化させることが可能であり、水中翼が発生する揚力の時間平均値の制御、さらには、より積極的に船体の振動抑制のための制御も小さな力で容易に行うことができる。

30 【0008】なお、回転軸 3 の位置は、翼としての効率を大きくするために、翼の空力中心より若干前方とするのが好ましい。この例では、船体は双胴型となっている。この場合、水中翼の形状を制御しない場合には、船体の重量の一部は排水量により受けもたせ、船体の姿勢の自立安定性を保たせることが好ましい。一方、翼形状をそのときの走行状態および船体の姿勢に応じて制御する場合には、船体を完全に浮上させて走行することが可能となり、走行時の抵抗はより一層小さくなる。

## 【0009】

【作用】図 2 に、本発明において用いる水中翼の作動原理を説明するための図を示す。図 1 において、水中翼 2 の翼断面形状が翼後部 5 が上方に跳ね上がった形状となっていたが、このような形状とする理由は、この翼を一樣流中に置いたとき、翼上下面の圧力差の分布が図 3 に示すごとくなり、翼全体として揚力を生じるある迎角において、ブレードの回転軸 3 のまわりに翼前部 6 から作用するモーメント（翼の迎角を小さくしようとする向きに作用するモーメント）を、翼後部 5 から作用するモー

メントが打ち消すようにするためである。このようにすることにより、回転軸 3 により支持された翼は、図 2

(b) に示すように流体の流れの中で揚力を発生する迎角を持った状態で安定化する。この例では、翼全体としての揚力は、翼前部 6 に作用する揚力 8 と、翼後部 5 に作用する負の揚力 7 との合力に等しい。なお、揚力 7 の作用点を、揚力 8 の作用点と比べ回転軸 3 から遠ざけるほど、より小さな力で揚力 8 と釣り合うモーメントを発生することができる。

【0010】ここで、例えば、波浪等の影響により船体が頭上げ状態となり、回転軸 3 と軸受け 4 との摩擦抵抗の為に、船体の回転に追従して一時的に水中翼の迎角が増加したとすると、図 2 (a) に示す様に翼後部 5 に働く下向きの力 7 が減少し、また翼前部 6 に働く上向きの力 8 は増加する。それにより頭下げのモーメント 9 が回転軸 3 のまわりに生じ翼迎角は減少する。逆に、船体が頭下げ状態となり、翼からみた迎角が減少した場合には図 2 (c) に示す様に翼後部に働く下向きの力 7 が増加し、また翼前部に働く上向きの力 8 は減少する。それにより頭上げのモーメント 10 が回転軸 3 のまわりに生じブレード迎角は増加する。このようにして、翼迎角は最終的に図 2 (b) に示すようなある迎角に自動的におちつく。すなわち、船体の姿勢変動にかかわらず、水中翼 2 は水流に対して一定の迎角を保持する。

【0011】よって、図 4 (a) ~ (c) に示すごとく、船体の姿勢によらずに翼は水流に対して、自動的に一定の迎角を保持することが可能となり、ほぼ一定の揚力(と抗力の合力)を、回転軸 3 を介して、船体に対して作用させることが可能となる。なお、回転軸 3 の回転摩擦抵抗を小さくするほど、また、翼の質量を小さくするほど、外乱に対する翼の迎角調整の動作の応答性は高くなる。ここで走行状態に応じて、翼後部のはね上げ角を制御することにより、水中翼が発生する力の大きさを調節することが可能となる。例えば、船体の速度が大きくなるにしたがって、翼の形状を翼の迎角が小さい値で安定化するような形状にしていくことにより、翼の発生する揚力を船体の速度によらずに一定値に保たせることが可能となる。

【0012】こうすることにより、例えば、常に船体の重量の一部を排水量により受けもたせ、船体の自立安定性を保持することが可能となる。また、波等の外乱による船体の振動を抑制する目的で、翼の発生する揚力を制御することも可能である。この例として、船体の重量すべてを水中翼により発生する揚力に受けもたせ、波等の外乱により船体に作用する時間的に変動する力に対処するために、翼形状を制御することが考えられる。

【0013】図 5 に示すように、翼を幅方向に分割して支持することにより、流れの向きが幅方向に不均一な場合において、各翼 2-1 ~ N の迎角の差を小さくすることが可能となり、翼全体としての効率が向上する。ま

た、各翼の翼後部 5-1 ~ N のはね上げ角を制御することにより、各翼に作用する揚力を個別に制御することが可能となり、船体のローリング方向の姿勢制御が可能となる。

【0014】なお、翼の形状としてはこの例に限らず、回転軸により支持されたとき、流体の流れの中で揚力を発生する迎角を持った状態で安定化するような 3 次元形状であればどんな形状であってもよく、また、補助翼を付加することにより同様な効果を生じさせてもよい。また、翼面荷重が大きい等の理由で、キャビテーションの発生が抑制出来ない場合は、翼型としてはスーパーキャビテーション翼型が好適である。また、翼が船体に触れるのを防止する等の目的で、軸受け 4 と回転軸 3 に拘束を設け、水中翼 2 がある範囲内でのみ回転を許されるようにしてもよい。

【0015】図 6 に、水中翼の翼形状の一例を説明するための図を示す。この例では、水中翼 2 は、揚力発生部 11 とその両端に取り付けられた迎角制御部 12 よりなっている。揚力発生部 11 はその空力中心付近に位置する回転軸 3 により支持され、迎角制御部 12 は揚力発生部 11 の後縁付近に位置する回転軸 13 により支持されている。迎角制御部 12 と揚力発生部 11 との相対迎角差は、回転軸 13 を介してサーボモーターにより任意の角度に制御される。迎角制御部 12 を揚力発生部 11 に対して負の迎角を持つように固定すると、水中翼 2 は流れの中で、揚力を発生する迎角で安定化する。

【0016】なお、発生する揚力ベクトルは、支柱 14 の角度に依存せず、したがって、船体のピッチング方向の角度にも依存しない。図 7 に、水中翼の翼形状の一例を説明するための図を示す。この例では、水中翼 2 は、揚力を発生する主翼 15 と、主翼を流れのなかで一定の迎角で安定化させるための補助翼 16 と、主翼と補助翼とを固定する支持構造 17 より構成されている。

【0017】

【実施例】図 8 に、本発明を滑走型の船舶に適用した実施例を示す。滑走時において、船体は水中翼より船体重量の半分程度を支持されるようにすると、抵抗が小さくなり小さな動力で大きな速度を達成することが可能になるとともに、半分程度の重量を滑走面からの力により支持することにより、姿勢の自立安定性を維持することが可能となる。

【0018】図 9 に、本発明を滑走型の船舶に適用した実施例を示す。この例では、回転軸 3 の位置を船体の重心位置 18 付近としている。このようにすることにより、船体の姿勢変動時において、水中翼から作用する力が船体のピッチング方向の回転モーメントとならないようにすることが、可能となる。

【0019】

【発明の効果】以上に述べたように、本発明では、迎角を変化させる方向の回転を自由に許す軸受けにより支持

10

20

30

40

50

され、流体の流れの中で揚力を発生する迎角で安定化する形状の水中翼を付与した船舶とすることにより、波等の外乱により船体にピッチング方向の姿勢変動が生じた場合において、流体の流れに対する水中翼の迎角を不変とすることが可能となり、以て、水中翼の発生する揚力を不変とすることが可能となり、船体の姿勢変動の影響を受けにくい水中翼を有する船舶を提供することが可能となる。

【図面の簡単な説明】

【図 1】本発明による、船舶の基本構成を説明するための図。

【図 2】本発明による、翼迎角の自動最適化の原理を説明するための図。

【図 3】本発明による、水中翼の翼上下面の圧力差分布。

【図 4】本発明による、船舶のピッチング振動時において、水中翼が発生する流体力の大きさ及び方向が不変となるメカニズムを説明するための図。

【図 5】本発明による、水中翼の構成例を説明するための図。

【図 6】本発明による、水中翼の構成例を説明するための図。

【図 7】本発明による、水中翼の構成例を説明するための図。

20

\*

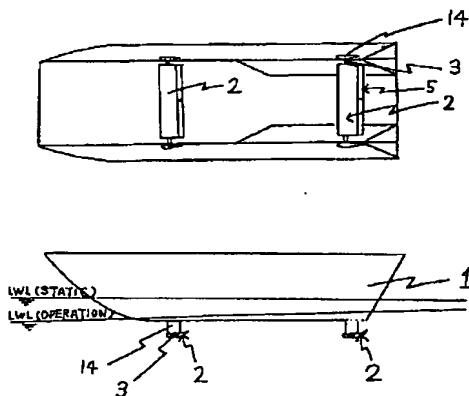
\* 【図 8】本発明を、滑走型の船舶に適用した実施例。

【図 9】本発明を、滑走型の船舶に適用した実施例。

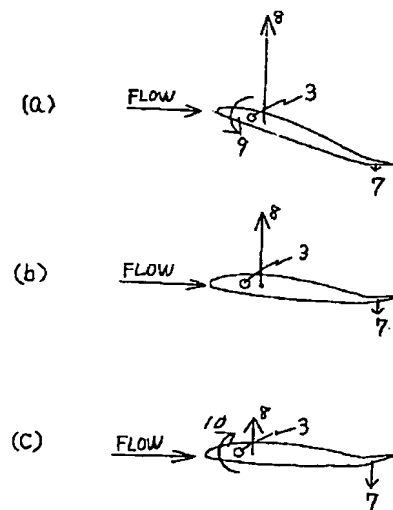
【符号の説明】

- 1 船体
- 2 水中翼
- 3 回転軸
- 4 軸受け
- 5 翼後部
- 6 翼前部
- 7 翼後部に作用する揚力、または、揚力と抗力の合力
- 8 翼前部に作用する揚力、または、揚力と抗力の合力
- 9 頭下げモーメント
- 10 頭上げモーメント
- 11 揚力発生部
- 12 迎角制御部
- 13 迎角制御部 12 の回転軸
- 14 支柱
- 15 主翼
- 16 補助翼
- 17 支持構造
- 18 重心位置

【図 1】

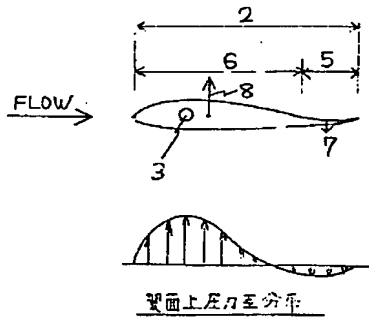


【図 2】

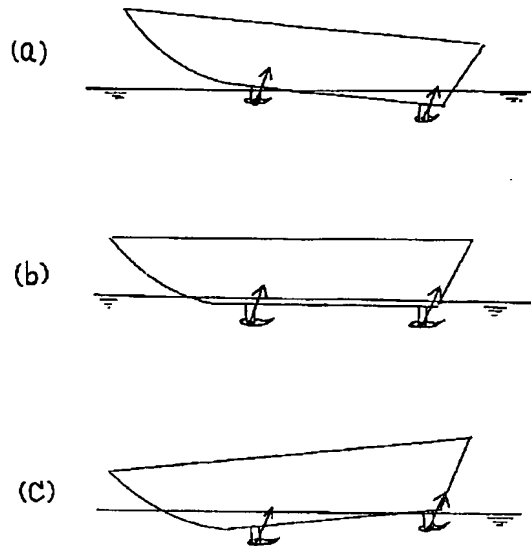




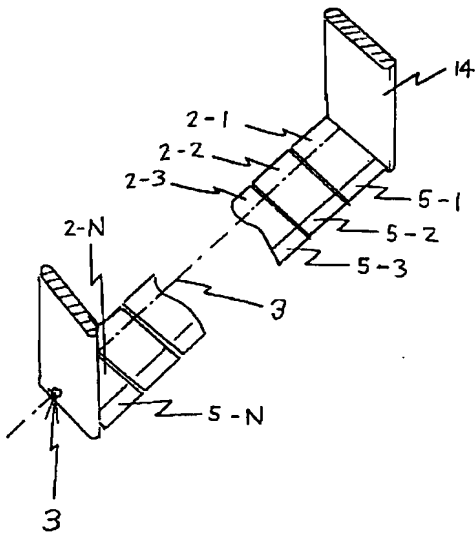
【図3】



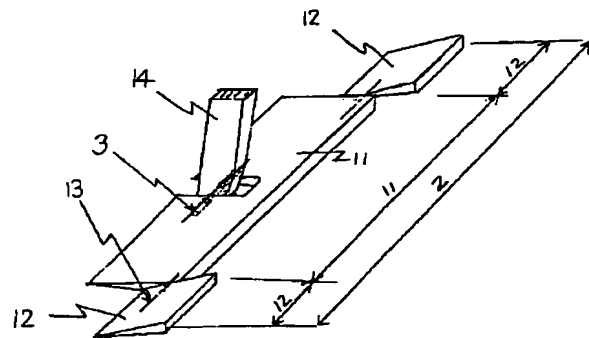
【図4】



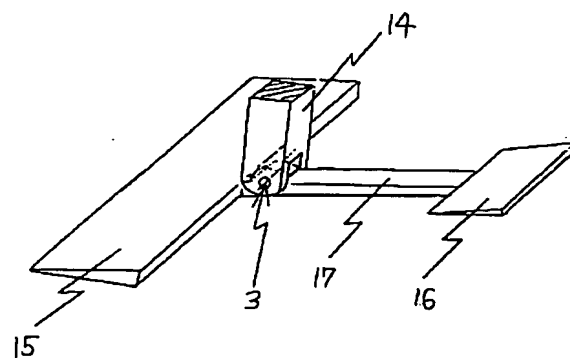
【図5】



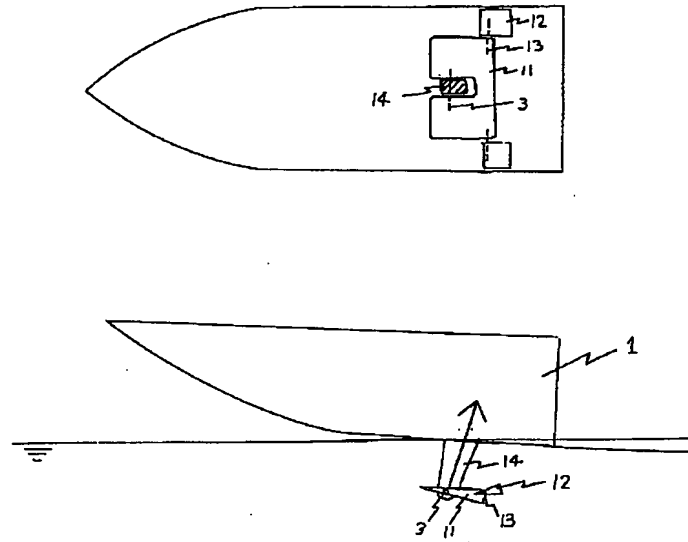
【図6】



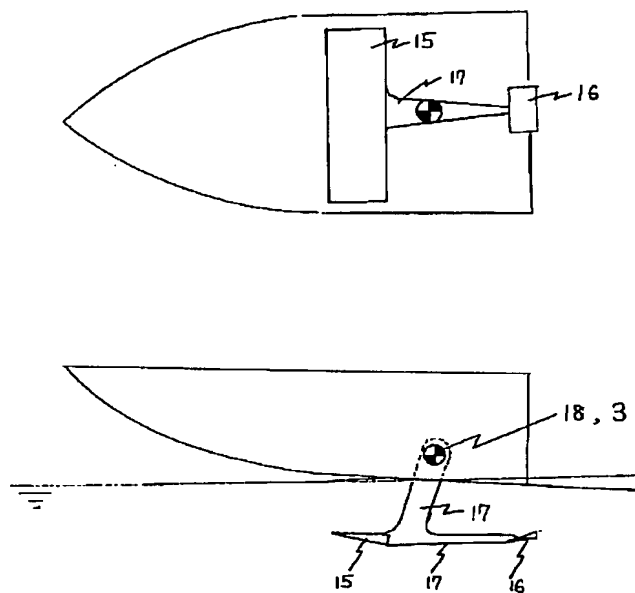
【図7】



【図 8】



【図 9】



## 【手続補正書】

【提出日】平成 5 年 12 月 20 日

## 【手続補正 2】

【補正対象書類名】明細書

【補正対象項目名】0008

【補正方法】変更

【補正内容】

【0008】なお、回転軸 3 の位置は、翼としての効率

を大きくするために、翼の空力中心より若干前方とするのが好ましい。この例では、船体は双胴型となっている。この場合、水中翼の形状を制御しない場合には、船体の重量の一部は排水量により受けもたせ、船体の姿勢の自立安定性を保たせることが好ましい。一方、翼形状をそのときの走行状態および船体の姿勢に応じて制御する場合には、船体を完全に浮上させて走行することが可

能となり、走行時の抵抗はより一層小さくなる。この揚力自動安定化のメカニズムについてさらに若干の説明を行う。翼後縁が跳ね上がった形状の翼では、空力中心まわりのモーメント係数は正（前縁を持ち上げる方向、換言すると、迎角 $\alpha$ を増大させる方向）となり、回転軸3の位置を空力中心より前方（前縁寄り）とすることにより、翼は一樣流の中で正の揚力を発生する迎角で安定化する。一般に、負のキャンバー（負の反り比）を持つ翼の空力中心まわりのモーメント係数は正となり、前縁からの最大反り位置が後縁に近いほどこの傾向は増大し、揚抗比を悪化させずにモーメント係数を増大させるには後縁近傍を調整し後縁が跳ね上がった形状とするのが好ましい。なお、翼としての効率を大きくするために、翼の空力中心まわりのモーメント係数は+0.01~0.1程度と小さな正の値であることが望ましく、従って、回転軸2の位置は、翼の空力中心より若干前方とするのが好ましい。各種翼型の形状および特性の関係は、I. H. Abbott et al., Summary of Airfoil Data, NACA Report No. 824, (1945), I. H. Abbott and A. E. vonDoenhoff, Theory of Wing Sections, Dover\*

\* Publications, Inc., N. Y., (1959), F. W. Riegels, Aerofoil Sections, Butterworths, London (1961)等で詳細に調査されている。本発明を実施する際には負のキャンバーを有する翼型を採用するケースが多くあるが、翼弦線に対して互いに鏡像の関係にある翼型については、翼弦線と垂直なy座標軸を反転させればよく、すなわち、迎角 $\alpha$ 、揚力係数 $C_L$ 、モーメント係数 $C_M$ は符号を逆にして考えればよいので、この場合にも前記文献の豊富なデータを利用することができる。なお、翼全体についても前述と同様、翼全体の空力中心まわりのモーメントが正となるような形状とし、かつ、回転軸3の位置を翼全体の空力中心より若干前方（翼前縁寄り）とすることにより、この翼全体は流れのなかで揚力を発生する迎角 $\alpha$ で安定化する。

【手続補正3】

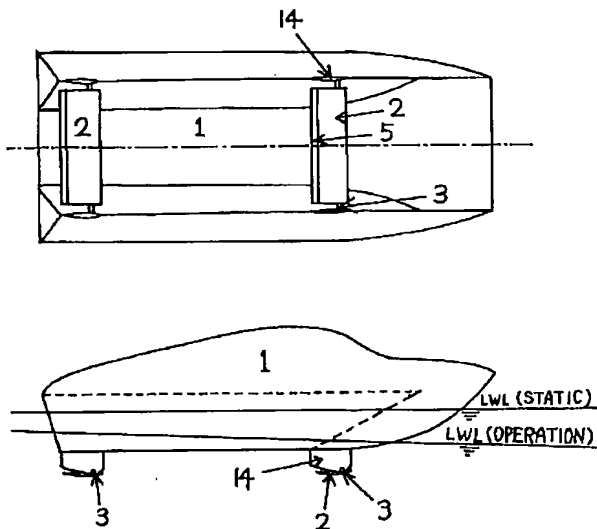
【補正対象書類名】図面

【補正対象項目名】全図

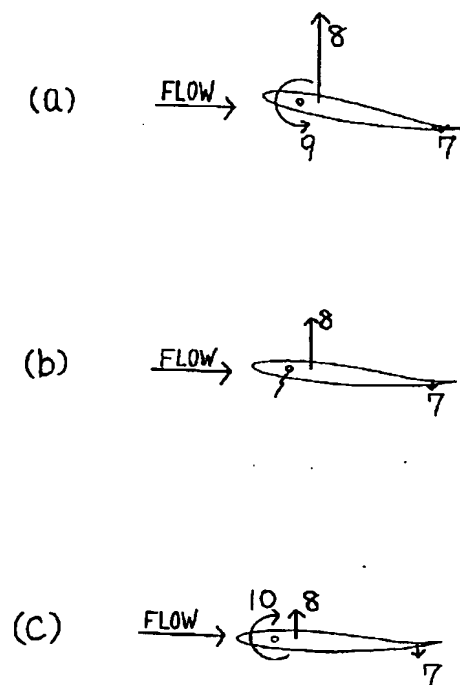
【補正方法】変更

【補正内容】

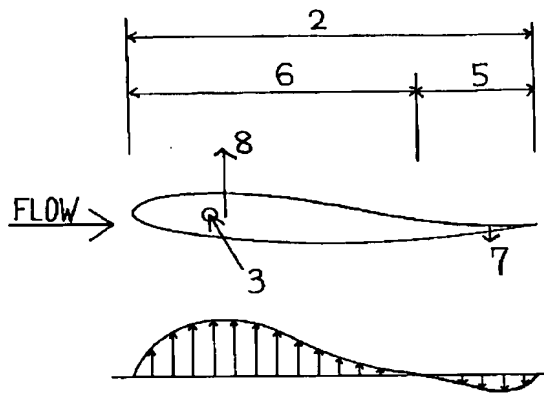
【図1】



【図2】

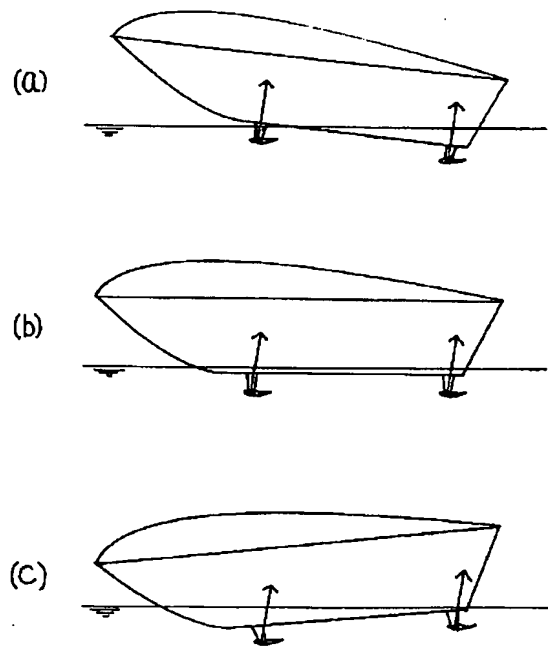


【図3】

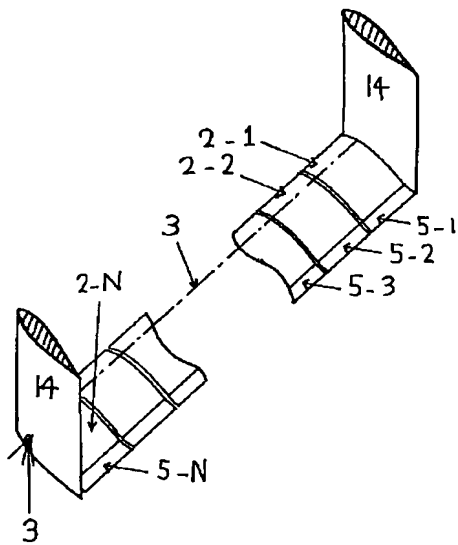


翼面上圧力差分布

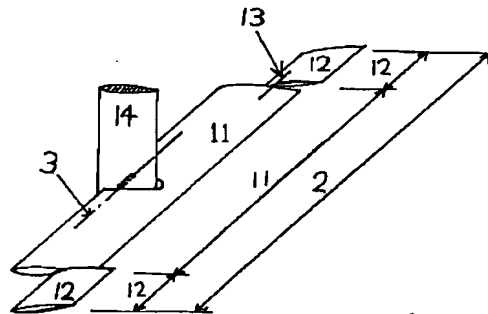
【図4】



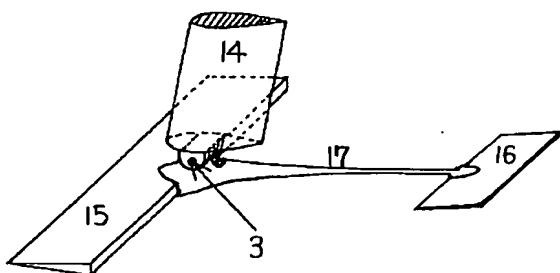
【図5】



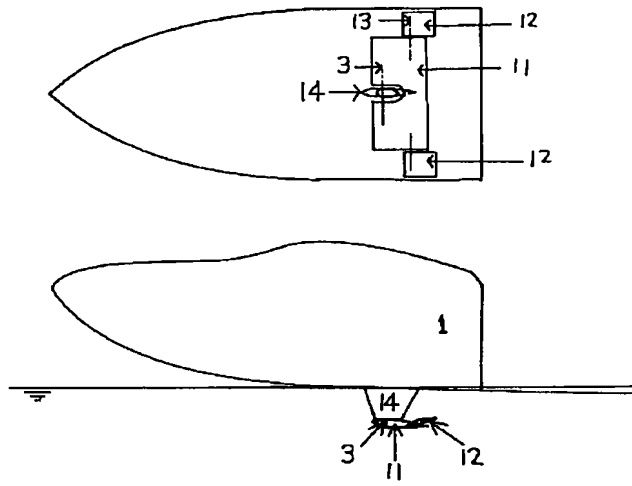
【図6】



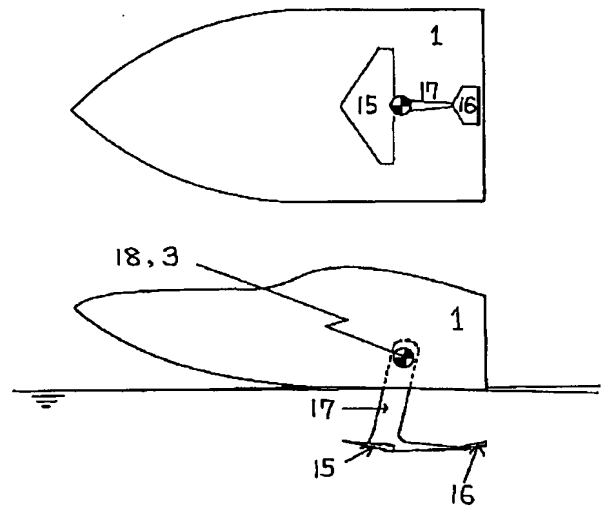
【図7】



【図8】



【図9】



**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☒ BLACK BORDERS

☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES

☐ FADED TEXT OR DRAWING

☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING

☐ SKEWED/SLANTED IMAGES

☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS

☐ GRAY SCALE DOCUMENTS

☐ LINES OR MARKS ON ORIGINAL DOCUMENT

☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY

☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**